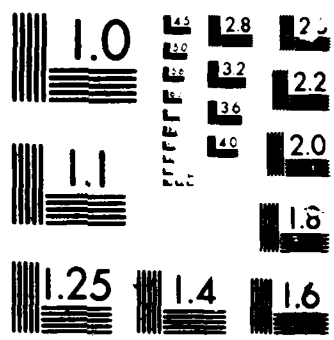
AD-A175 940 FORECASTING ATMOSPHERIC SONIC PROPAGATION AT THE EASTERN TEST RANGE(U) EASTERN SPACE AND MISSILE CENTER PATRICK AFB FL B F BOYD ET AL JAN 87 ESMC-RR-87-02 1/1

UNCLASSIFIED F/G 20/1 NL


1.0
2.8
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

AD-A175 940

1b RESTRICTIVE MARKINGS	None
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
3 DISTRIBUTION/AVAILABILITY OF REPORT	Approved for public release; distribution unlimited.
4 PERFORMING ORGANIZATION REPORT NUMBER(S)	None
5 MONITORING ORGANIZATION REPORT NUMBER(S)	ESMC-TR-87-02
6a NAME OF PERFORMING ORGANIZATION	Eastern Space and Missile Center
6b OFFICE SYMBOL (If applicable)	WER
7a NAME OF MONITORING ORGANIZATION	ETR/RA, STINFO, Ms Brown, 854-2803
6c ADDRESS (City, State and ZIP Code)	Patrick AFB, FL 32925
7b ADDRESS (City, State and ZIP Code)	Patrick AFB, FL 32925
8a NAME OF FUNDING/SPONSORING ORGANIZATION	
8b OFFICE SYMBOL (If applicable)	
9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
8c ADDRESS (City, State and ZIP Code)	

10 SOURCE OF FUNDING NOS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT NO

11 TITLE (Include Security Classification)	Forecasting Atmospheric Sonic Propagation at the Eastern Test Range
12 PERSONAL AUTHOR(S)	Boyd, B.F. and K.B. Overbeck
13a TYPE OF REPORT	Information
13b TIME COVERED	FROM 1/83 TO 12/86
14 DATE OF REPORT (Yr, Mo, Day)	87 JAN
15 PAGE COUNT	4
16 SUPPLEMENTARY NOTATION	

17 COSATI CODES

FIELD	GROUP	SUB GR

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

Forecasting, Sonic Propagation, Models,

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

The BLAST Damage Assesment Model was installed at the Eastern Test Range (ETR) in 1981 to evaluate inadvertent detonation hazards as a function of meteorological conditions. This paper describes the improved model and its use both as a planning tool and operational decision maker to support launches from the ETR. The meteorological parameters affecting the model are presented, their influence explained, and the variability of atmospheric propagation forecasts with different meteorological conditions presented.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT	UNCLASSIFIED/UNLIMITED X SAME AS RPT. ☐ DTIC USERS ☐
21 ABSTRACT SECURITY CLASSIFICATION	Unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL	B.F. Boyd
22b TELEPHONE NUMBER (Include Area Code)	494-5915
22c OFFICE SYMBOL	ESMC/WER

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE

87 1 12 034

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

ESMC-TR-87-02

FORECASTING ATMOSPHERIC SONIC PROPAGATION AT THE EASTERN TEST RANGE

Billie F. Boyd
Karl B. Overbeck
ESMC/WE Staff Meteorologist
Patrick Air Force Base, Florida 32925

January 1987

Information 1983 - 1986
(Final)

Approved for Public Release;
Distribution Unlimited

Prepared for
EASTERN TEST RANGE
RANGE SUPPORT OFFICE
PATRICK AIR FORCE BASE, FLORIDA 32925

FORECASTING ATMOSPHERIC SONIC PROPAGATION AT THE EASTERN TEST RANGE

Billie F. Boyd
Office of the Staff Meteorologist
Eastern Space and Missile Center
Patrick Air Force Base, Florida
and
Karl B. Overbeck
NTS Engineering
Long Beach, California

Abstract

The BLAST Damage Assessment Model was installed at the Eastern Test Range (ETR) in 1981 to evaluate inadvertent detonation hazards as a function of meteorological conditions. This paper describes the improved model and its use both as a planning tool and operational decision maker to support launches from the ETR. The meteorological parameters affecting the model are presented, their influence explained, and the variability of atmospheric propagation forecasts with different meteorological conditions presented.

Background

The BLAST Damage Assessment Model addresses intermediate range effects of a shock wave from an inadvertent detonation. Near-in areas of overpressures above about one pound per square inch (psi) are evacuated and therefore are not considered by the model. At a far enough distance, there are of course no problems. It is the intermediate distance with psi of 0.1 to about 0.5 which are of concern. This area of values varies considerably according to local meteorological conditions.

Intermediate range airblast effects for early generation launch vehicles presented little or no risk to nearby areas, but population encroachment and increased explosive yields led to problems. The solution to these problems was to impose very conservative launch limitations based on wind direction. The next approach was to eliminate the need for these conservative assumptions by conducting explosive tests to develop improved overpressure relationships; by analysis of the test data to determine its appropriate utilization; and by model development to reflect the analytical results. The effort has led to the real time operational use of the BLAST Damage Assessment Model for all Shuttle launches and now for Trident D-5 launch operations.

Problem

Three atmospheric parameters play major roles in sonic wave propagation: pressure, temperature, and wind. The relationship of the speed-of-sound profile and the focusing of shock waves is based on the following physical principle: when the speed of sound decreases with height, the shock waves are refracted upwards; when the speed of sound increases with height, the shock waves are refracted downward. Many different speed-of-sound profiles are possible. Simplified examples are illustrated in Figures 1-4. If there were no change of sonic velocity with altitude, a shock wave would expand spherically. This idealized case is shown in Figure 1 as the standard. Such an atmospheric condition never exists in the earth's atmosphere where sonic velocity normally decreases with altitude. This produces shock waves that bend upward and attenuate (as illustrated in Figure 2). Basic physics predicts such ray-turning for all waves (light, sound, etc.). For intermediate range airblast effects, the acoustic approximation is appropriate. The general rule is that an acoustic ray will turn away from an area of higher sonic velocity (index of refraction). An inversion condition, where sonic velocity increases with altitude, caps the shock wave and turns the rays back to the ground yielding an enhanced overpressure (as illustrated in Figure 3). The greatest enhancement arises under a caustic propagation condition where the sonic velocity first decreases from its surface value and then increases beyond its surface value. An atmospheric lens can then focus shock waves to very high amplifications relative to standard. Figure 4 illustrates this case.

Solution

The principal hazards arising from intermediate range airblast effects are injuries due to window breakage in the nearby local communities. The prinicpal inputs to the BLAST

Dist | Avail and/or Special
A-1

87 1 12 03

Damage Assessment Model are meteorological data, explosive yield and location, and window survey data giving the numbers and locations of windows in the nearby communities. For each 30 degree section over land, the model computes the overpressure at each window centroid, the expected window breakage there, and the casualty estimate (as a function at the number of windows broken). Launch criteria are defined in terms of an acceptable window breakage which will not yield an unsatisfactorily high casualty estimate. During launch operations, the BLAST Model is exercised with real time meteorological inputs and the model results are compared to the launch criteria to identify unacceptable conditions. A schematic of the BLAST Model is presented in Figure 5.

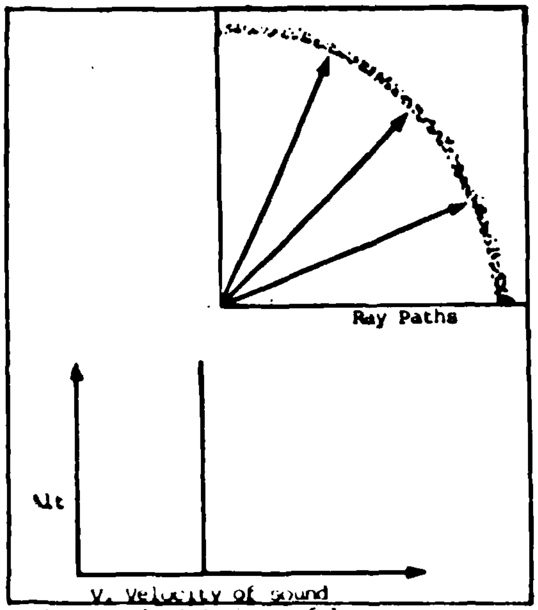


Fig 1. Standard Sonic Profile

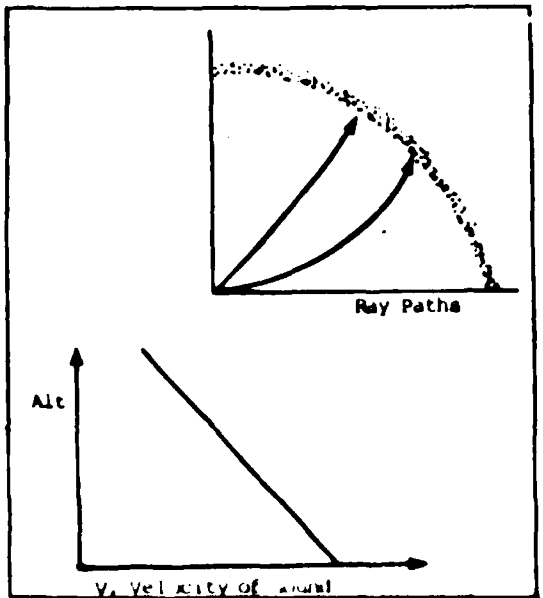


Fig 2. Gradient Sonic Profile

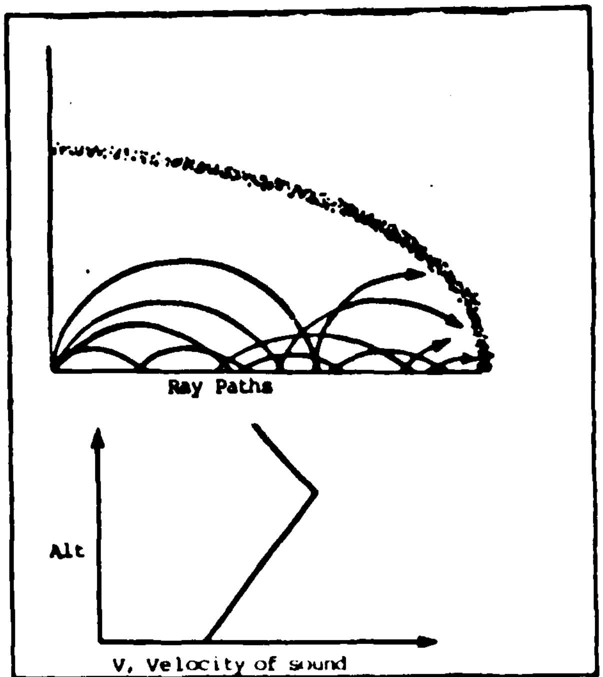


Fig 3. Inversion Sonic Profile

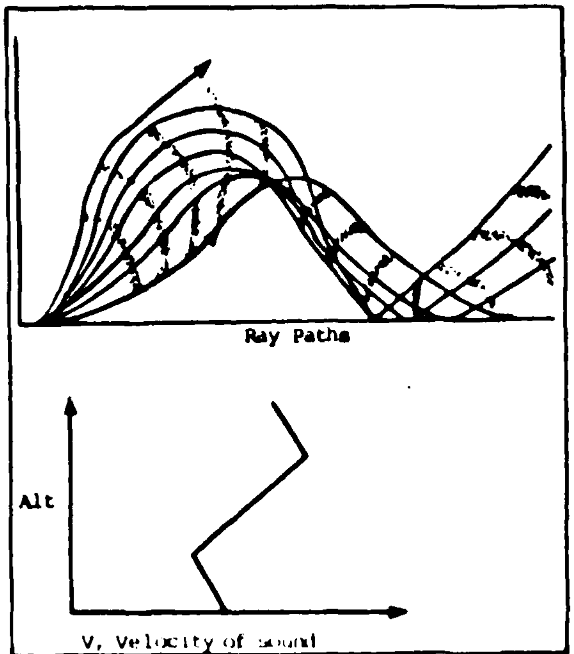


Fig 4. Caustic Sonic Profile

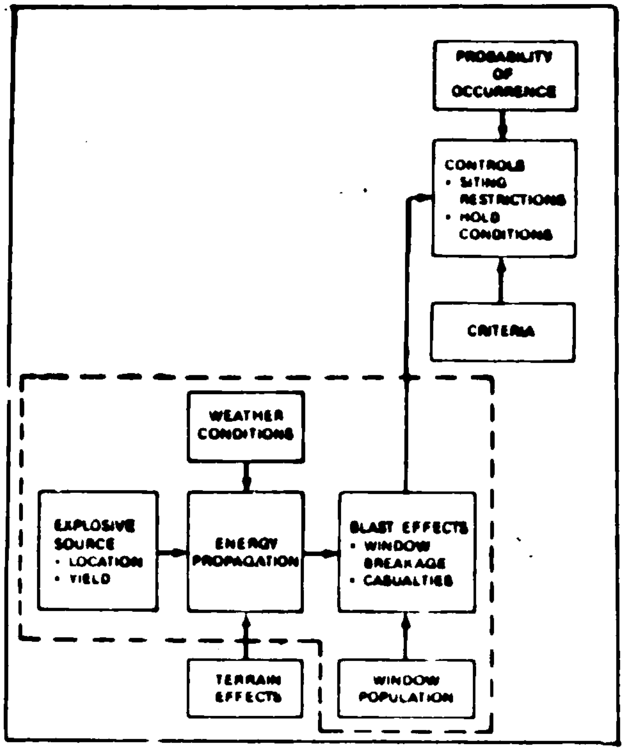


Fig 5. BLAST Model Schematic

Operational Example

Table 1 presents the BLAST Model results accumulated during STS-51C which was launched at 1440 Eastern Standard Time, January 24, 1985. The first full column of data presents the Greenwich Mean Time (or Zulu Time) when wind tower data were obtained. The weather inputs to the BLAST Model for launch operations consist of low-altitude wind tower data (up to 150 meters) merged with upper-altitude rawinsonde data. Updated wind tower data are available more frequently than updated rawinsonde data. For example, in Table 1, 25 sets of low-altitude tower data have been merged with upper-air data from seven rawinsonde releases. The time difference involved in this merging technique is an area of significant concern. The next three data columns in Table 1 present the window breakage results computed by the BLAST Model. The unvaried results (i.e., raw data) are computed using the input weather data to define the type and strength of the propagation condition. Since the test data analysis indicated that the meteorological uncertainty contributed greatly to the risk, a Monte Carlo methodology has been implemented to estimate this risk. The second column lists the average breakage of one hundred Monte Carlo variations of the meteorological input data, assuming that each temperature, wind direction, and wind speed value is normally distributed about its measured value. The next column lists the ninetieth highest breakage result of the hundred Monte Carlo variations. These three breakage results are compared with the launch criteria to define unacceptability. The final columns list the local surface temperature and the balloon release time for the rawinsonde data.

January 24, 1985 exhibited unusually cold Florida weather. In the cold air mass, the clear night radiational cooling created a surface inversion. With that condition, the BLAST Model indicated light window breakage and therefore no launch problem from the aspect of BLAST damage. After sunrise and the start of surface heating, conditions changed significantly. A temperature inversion at about 4000 feet, combined with the surface heating, created a caustic condition which increased the window breakage values from the BLAST Model. Movement of the upper level ridge by mid day resulted in a weakening of the temperature inversion and a small wind shift, sufficient to bring forecast breakage back into limits. A change in the sonic velocity along the due south radial can be seen by comparing Figures 6 and 7. These figures show the difference in speed, by altitude, compared with the surface value. In each figure, the vertical axis is altitude in thousands of feet and the horizonal axis is the speed at that altitude substracted from the surface value (in feet per second). The input data for these two figures are given in Tables 2 and 3. Note in particular, the 22 degree wind shift at 3000 feet and the temperature drop of 4.2 degrees at 4000 feet.

Tower Data Time	Unv	Avg	90 Pct	Surface Temp	Rawin Data Time
930	12.08	16.17	24.69	28.	715
1000	11.70	17.34	36.17	31.	715
1030	7.07	14.15	34.49	33.	715
1100	34.61	24.96	61.20	33.	945
1130	115.44	31.91	81.88	34.	945
1200	10.23	32.88	85.94	33.	945
1230	13.06	30.47	63.13	33.	945
1300	24.25	56.83	135.63	36.	945
1330	16.38	69.95	186.51	40.	945
1400	363.75	444.42	778.37	46.	1314
1430	346.52	438.71	771.96	48.	1314
1500	287.72	470.90	751.66	52.	1314
1530	112.07	329.32	580.80	54.	1437
1600	111.52	309.58	554.35	56.	1437
1630	188.81	320.41	574.10	57.	1437
1700	185.15	255.32	411.73	60.	1437
1730	217.83	352.50	559.04	61.	1640
1800	341.29	334.16	562.03	62.	1640
1830	124.60	336.93	558.09	64.	1640
1900	10.88	139.59	286.76	65.	1814
1930	10.66	147.59	315.97	66.	1814
2000	10.81	140.50	336.87	67.	1814
2030	8.08	128.97	280.38	67.	1814
2100	0.00	68.94	176.36	68.	1954
2130	0.00	74.15	244.88	67.	1954

Table 1. BLAST output for STS-51C. Unv: Unvaried; Avg: Average of 100 Monte Carlo cases; 90 Pct: 90% wort case, Surface Temp: °F.

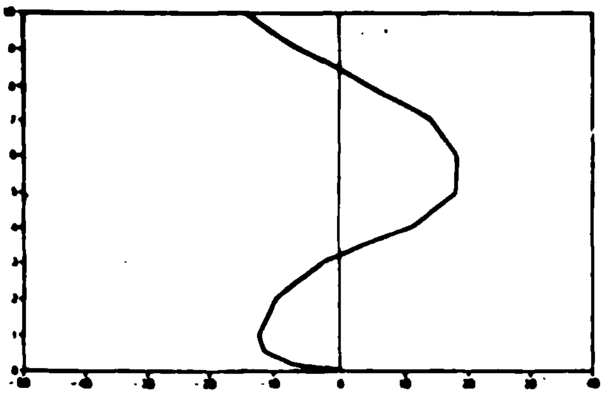


Fig 6. Difference in the velocity of sound, from surface value, along the 180^{O} azimuth at 1720Z

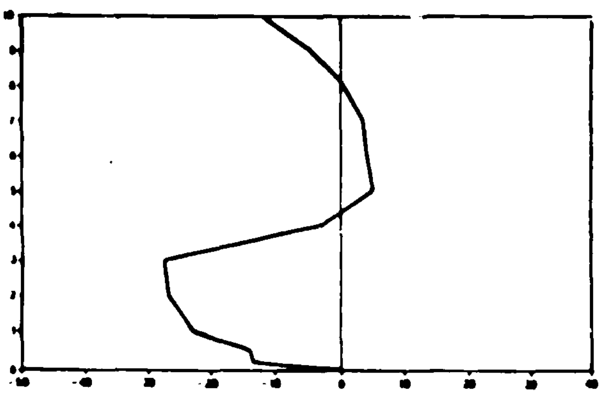


Fig 7. Difference in the velocity of sound from surface value, along the 180^{O} azimuth at 1845Z

Height (ft)	Dir (deg)	Spd (kts)	Tmp (°C)	Dew (C)	Press (mbs)
00012	000	000	15.6	4.2	1022.0
00204	254	008	13.6	3.5	1014.0
00492	250	000	12.4	3.3	1004.5
01000	267	000	10.6	2.6	985.1
02000	281	016	8.2	4.0	940.7
03000	280	022	8.4	1.7	915.4
04000	707	027	10.6	2.5	882.4
05000	302	036	9.3	3.6	850.7
06000	302	037	8.8	1.2	820.1
07000	300	038	6.7	1.6	790.4
08000	283	038	4.9	4	761.6
09000	284	041	4.7	-4.5	733.8
10000	278	046	3.8	-8.9	706.8

Table 2. Date input for 1720Z BLAST run (data above 492 ft are from rawinsonde released at 1640Z)

Height (ft)	Dir (deg)	Spd (kts)	Tmp (°C)	Dew (C)	Press (mbs)
00012	080	080	17.8	5.2	1018.0
00204	238	011	15.8	4.7	1011.9
00492	242	011	15.0	4.5	1001.5
01000	244	009	10.0	1.6	982.5
02000	258	014	7.8	2.5	947.1
03000	287	018	5.1	1.8	912.6
04000	286	028	6.4	1.5	879.3
05000	288	031	8.4	1.9	847.5
06000	287	036	7.0	0.4	816.8
07000	286	038	5.5	-0.8	787.1
08000	284	041	4.2	-2.3	758.3
09000	281	044	2.4	-2.8	730.4
10000	287	046	0.9	-4.3	703.4

Table 3. Data input to 1845Z BLAST run (data above 492 ft are from rawinsonde released at 1814Z)

Summary

In summary, use of the BLAST Damage Assessment Model has eased prohibitive launch restrictions by eliminating the need for conservative assumptions. However, use of the model requires reasonably valid meteorological input values. Forecasting problems occasionally occur, such as: the magnitude, altitude, and persistence of temperature inversions and/or wind shifts.

References

1. Overbeck, K. B. (1981): Certification Documentation for the Blast Damage Assessment Model, Technical Report 81-1410, J. H. Wiggins Company.

2. Overbeck, K. B. (1985): Draft Documentation for the Correlated Blast Damage Assessment Model, Technical Report 85-3119-03-d (Air Force Contract No. F04703-83-C-0301) J. H. Wiggins Company.

3. Rasmussen, R. A. (1971): A Prediction Method for Blast Focusing, USAFETAC TN71-8, 34pp.

END
2-87
DTIC